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ABSTRACT

The research reported in this paper is concerned with the ability of students of English as a second language (ESL) to apply cognitive skills in reading. The paper focuses on: (1) a validation study of an experimental test designed to measure Piagetian concrete operations in reading and (2) the effects of the paragraph types (additive or multiplicative, classification or seriation) and the item types (easy or difficult, emphasizing intension or extension) in the Piagetian test. The subjects were 28 students of various language backgrounds enrolled in full-time intensive English classes at a university ESL center. The questions following the paragraphs were either easy or difficult in terms of the number of logical steps required to process them, and they emphasized either intension or extension. Analysis of the students' responses to the questions found that all four factors had significant effects, with some significant interactions. Overall, the Piagetian test was found to have higher construct validity than the Test of English as a Foreign Language (TOEFL) in measuring the application of logical skills to reading. (MSE)

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Measuring ESL Subjects' Ability to Perform Piagetian Concrete Operations in Reading

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Abstract

This paper reports an attempt to assess ESL students' ability to apply thinking in reading. The paragraphs used in the experimental test were based on classification and seriation cognitive abilities. The item types were either difficult or easy, based on the number of logical steps necessary to process the question and were either extension or intension based.

The results indicate that the experimental test has strong construct validity and that there were significant effects for the paragraph types and the item types.

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Introduction

This paper has two foci: (1) to report a validation study of an experimental test which was designed to measure Piagetian concrete operations in reading and (2) to study the effects of the paragraph types and the item types in the Piagetian reading test.

To establish some background for the Piagetian concrete operations test, it will be necessary to review Piaget's theory of cognitive development which is divided into four stages: (1) the sensory-motor stage (birth to two years), (2) preoperational thought which is divided into two substages: (a) symbolic thought (two to four years) and (b) intuitive thought (four to seven years), (3) concrete operations (seven to eleven years), and (4) formal operations (eleven to fifteen years).

During the sensory-motor stage the child begins to notice the existence of objects, objects which are separate from the child. In the stage of symbolic thought the child is able to differentiate between an object and its symbol. Egocentricity marks the stage of intuitive thought, because words have been ascribed private meanings. The child reaches the stage of concrete operations when s/he can covary at least two relationships simultaneously. The well-known conservation tasks have been used to test the child's competence at concrete operations--tasks, for example, which entail that the child compensate while determining that a tall, thin beaker contains the same quantity of liquid as a squat, wide beaker. And finally in the formal operations stage, the child begins to think in the abstract and to test hypotheses.

During the concrete operations stage the child's logical powers are concentrated in two different kinds of mental operations: (1) classification which involves class inclusion (the relation between part and whole) and (2) seriation which involves thinking both backward and forward simultaneously.

Classificatory and serial behaviors are manifested by the addition and multiplication of classes and relations. Addition involves the following activities: (1) the construction of a class hierarchy, (2) the establishment of each class's complements in the hierarchy, and (3) the establishment of an ordered scale with classes or objects. Multiplication involves the following operations: (1) the establishment of a hierarchy by classifying identical members of a (sub)class according to two or more traits, (2) the comparison of a series of elements established on two or more ordered difference scales, and (3) the comparison of elements with regard to symmetrical or asymmetrical relations.

Kretschmer (1972) developed a reading comprehension test which was based on the aforementioned concrete operations. It must be pointed out that Piaget and other developmental psychologists used concrete, tangible props to test children's logical powers. Kretschmer's test was the first verbal reading test based on concrete operations.

For the research reported in this paper Kretschmer's test was used to measure the ability of adult ESL students to apply reasoning to reading. The intent of this research is not to determine whether adult ESL students have achieved cognitive development, for they surely

have; however, the thrust of the research is to determine whether Kretschmer's test measures the same constructs as a standardized language proficiency test (the TOEFL) and to study the effects of paragraph types and item types.

The rationale for this study is anchored in research that suggests that language and intelligence are coterminus (e.g., Oller and Perkins, 1978), and reasoning and intelligence may also be related. In addition, there is research indicating that logical skills are important to the generation of a plausible text structure (e.g., Fisher and Smith, 1977). A reader must also utilize logical relations when processing single- and multiple-string inference questions and evaluation questions. And finally, there has been some research conducted on the effects of item types in a reading comprehension test (e.g., Perkins, 1984; Perkins and Jones, 1985).

Methodology

Subjects

This research was conducted at the Center for English as a Second Language at Southern Illinois University. The 28 subjects were enrolled in full-time intensive English classes at the Center. The distribution by native language was the following: Arabic, 10; Chinese, 2; Farsi, 2; Japanese, 3; Korean, 1; Malay, 4; Spanish, 4; Thai, 2.

Materials

Kretschmer's test contains four paragraphs, and each paragraph established one of the following operations: (1) an additive classification, (2) a multiplicative classification, (3) an additive series,

and (4) a multiplicative series. The paragraphs are dichotomous and form a 2 X 2 matrix. Figures 1 - 4 display the paragraphs.

The questions are also dichotomous and form a 2 X 2 matrix. The questions are either difficult or easy and emphasize either intension or extension. Question difficulty depends on the number of logical steps between assumptions in the additive hierarchies or the number of properties or ordered difference scales in the multiplicative hierarchies. Questions that emphasize intension present the property of a class or the relation of a series in the stem while questions that emphasize extension present or list the elements, objects, or subclasses or the series in the stem. Kretschmer's test has sixteen possible combinations of item types with two questions each yielding a total of 32 items. Figure 5 displays examples of the dichotomous nature of the question.

The subjects took the Piagetian reading test in class, and they were allowed fifty minutes to complete the test.

Research Questions

The research questions to be addressed in this paper are the following: (1) Would there be a meaningful relationship between the Piagetian reading test and the TOEFL? In other words, is the ability to apply thinking to reading also measured by the TOEFL? (2) Would there be significant differences between the subjects' performances on classification and seriation items? (3) Would there be significant differences between the subjects' performance on items following additive paragraphs and items following multiplicative paragraphs?

(4) Would there be significant differences between the subjects' performance on the easy and difficult items? (5) Would there be significant differences between the subjects' performance on items emphasizing intension and items emphasizing extension?

Analyses and Results

The means, standard deviations, estimates of reliability, standard errors of measurement, and validity coefficients are presented in Table 1.

Internal-consistency formulas such as the Kuder-Richardson 20 and 21 underestimate the reliability of a measure when it contains a wide dispersion of item difficulties, which is the case for the Piagetian reading test. In fact, the KR-21 assumes that the proportion of subjects who answered an item correctly will be constant for all items. Fortunately, there is a procedure which allows for variations in item difficulty: Horst's (1953) modification of the Kuder-Richardson 20 formula considers the extent to which the test approaches the maximum variance that a test could achieve with its given distribution of item difficulties. Horst's modification was applied to the Piagetian responses.

The first research question was answered by utilizing the internal construct validation procedure presented in Henning (in press). The internal construct validation procedure has the following steps: (1) calculate the point-biserial correlation between each Piagetian item and the total scores for the Piagetian test, (2) correct the value of each correlation for part-whole overlap, (3) calculate the

point-biserial correlation between each Piagetian item and the TOEFL scores. If a Piagetain item is more highly correlated with the Piagetian total than with the TOEFL, that item is said to have shown construct validity. The validity coefficients shown in Table 1 are the proportions of Piagetian items that showed construct validity when they were calculated with the TOEFL subtests and the TOEFL totals.

The results indicate that the Piagetian test has a high proportion of construct validity when it is compared with the TOEFL. In other words, the results indicate that the TOEFL does not measure the ability to apply reasoning in reading. These results should not be taken as a criticism of the TOEFL. A content analysis of the TOEFL reading comprehension items would surely produce a list of items that entail reasoning and logical thinking. The highest correlation corrected for unreliability was between the Piagetian test and the reading comprehension subtest (.64); a correlation of .53 obtained between the Piagetian test and the TOEFL Total. The extent to which logical thinking accounts for variance in a measure of second language proficiency is a matter that goes far beyond the scope of this paper.

To answer questions 2 - 5, the data were submitted to the analysis of variance procedure. The results are shown in Table 2.

The four factors investigated had significant effects. The classification items were more difficult than the serial items. Piaget (1967) claimed that for children, classes are more abstract than series because classes cannot be directly perceived while series present a good perceptually salient "form". The results from this

research indicate that Piaget's observation is also valid for adults.

The multiplication items were more difficult than the addition items. Multiplication items present a number of properties or ordered difference scales. This finding suggests that ESL readers have less difficulty with paragraphs which concern the members of a class or groups than they do with paragraphs which deal with the properties or traits of a class.

The difficulty factor produced the largest F-ratio. The difficult items involve greater structural distance in a hierarchy or a greater number of logical steps in terms of correctly answering a question. It could well be that the difficult questions measure a reader's short-term memory.

The intension items were more difficult than the extension items. Items which emphasize intension concern properties rather than members of classes. In sum, passages and items that deal with properties and traits were more difficult than those that deal with members of classes.

There were three significant interactions: (1) the paragraph types, (2) the item types, and (3) addition vs. multiplication paragraphs by extension vs. intension questions.

Because there were three significant interactions, one must qualify or modify any generalizations about the main effects of these variables in question. While significant effects were found for the two paragraph types and the two item types when they were analyzed separately, the fact that significant interactions obtained indicates that the significant effect of each may be due to the second factor in the interaction.

In sum, significant interactions dampen the importance of the main effects.

No three-way or four-way interactions were computed because the size of the data base did not warrant the computation of such complex interactions.

This research has addressed the ability of ESL students to apply thinking to reading. It was found that this construct is not measured by the TOEFL test, and the paragraphs based on classification and seriation cognitive abilities had significant effects on the responses as did the two different item types employed in the test.

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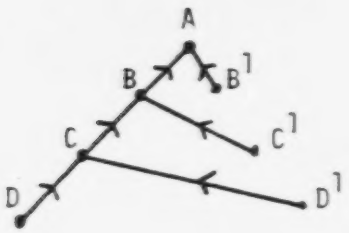
Figure 1

Additive Classification paragraph

Betty, Brad, Dan, Greg, and Karen go to Elm St. School. Greg is in the fifth grade, and the others are in fourth. All the fourth-graders like ice cream except Karen. Betty does not have a pet. The other fourth-graders who like ice cream do have pets. Dan has a dog.



A = children who go to Elm St. School

B = fourth-graders

B^1 = fifth-graders

C = children who like ice cream

C^1 = children who do not like ice cream

D = children who have pets

D^1 = children who do not have pets

"B is included in A"

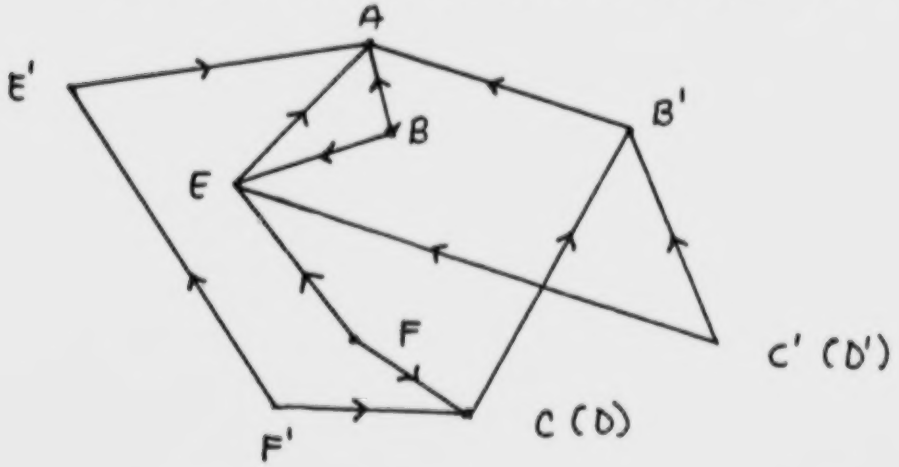
" > " : "included in"

(Kretschmer 1972:35)

Figure 2

Multiplicative classification paragraph

John had two brothers who were both tall. Their names were Will and Fred. John's sister, who was short, was named Mary. John liked Fred better than either of the others. All these children except Will had red hair. He had brown hair.



A = children in John's family

B = John

B^1 = children who are not John

C = John's brothers

C^1 = John's sisters

D = tall children

E = red-haired children

E^1 = brown-haired children

F = Fred

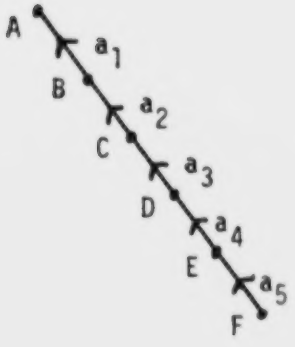
F^1 = Will

(Kretschmer 1972:36)

Figure 3

Additive series paragraph

I have five good friends. Bert lives right next door to me. Carol lives farther away than Bert. Jill lives even farther away than Carol. Dana lives farther away than Carol, but closer than Scott. I have to take a bus to his house.



A = I

B = Bert

C = Carol

D = Jill

E = Dana

F = Scott

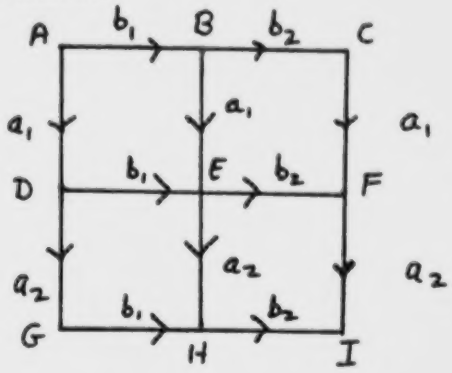
a = distance

(Kretschmer 1972:37)

Figure 4

Multiplicative series paragraph

There are nine boys on the Bears baseball team. Mark, Bill, and Ed are all taller than Henry or Dave or Bob. Jack, Ray, and Al are the shortest. Henry, Jack, and Mark run faster than Dave, Ray, or Bill. Bob, Ed, and Al are the slowest runners.



A = Mark

B = Bill

C = Ed

D = Henry

E = Dave

F = Bob

G = Jack

H = Ray

I = Al

a = taller

b = faster (Kretschmer 1972:37)

Figure 5

Easy/hard items; intension and extension items

Betty, Dan and Brad

a) have pets.
b) are in the fifth grade.
easy c) like ice cream.
d) do not have pets.
e) No answer is right.

Dan and Brad

a) are in the fourth grade.
b) do not have pets.
hard c) have dogs.
d) do not like ice cream.
e) No answer is right.

Who likes ice cream?

a) Dan, Betty and Brad
b) Greg, Karen and Betty
intension c) Brad, Betty and Karen
d) Betty, Greg and Brad
e) No answer is right.

Betty, Dan and Brad

a) have pets.
b) are in the fifth grade.
extension c) like ice cream.
d) do not have pets.
e) No answer is right.

Table 1

Test statistics

Test	$\bar{x}$	s	r_{tt}^{KR-20}	S_e	Validity
Piagetian Concrete Operations	22.18	3.24	.73	5.3	
TOEFL Listening Comprehension	51.33	5.60	.89	2.2	.90
TOEFL Structure and Written Expression	49.20	6.92	.87	2.7	.80
TOEFL Reading Comprehension	46.53	6.36	.89	2.3	.80
TOEFL Total	490.27	53.70	.95	13.9	.90

Table 2

ANOVA results

Effect of classification vs. serial paragraphs (A)	$F(1,27) = 13.66$	$p < .0010$
Effect of addition vs. multiplication paragraphs (B)	$F(1,27) = 6.45$	$p < .0171$
Effect of easy vs. difficult questions (C)	$F(1,27) = 20.96$	$p < .0001$
Effect of extension vs. intension questions (D)	$F(1,27) = 8.23$	$p < .0079$
Interaction of A by B	$F(1,27) = 14.25$	$p < .0008$
Interaction of C by D	$F(1,27) = 9.66$	$p < .0044$
Interaction of B by D	$F(1,27) = 6.42$	$p < .0174$
Interaction of B by C	$F(1,27) = 0.05$	$p < .8255$
Interaction of A by C	$F(1,27) = 2.39$	$p < .1336$
Interaction of A by D	$F(1,27) = 2.28$	$p < .1429$